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P. C. Hsu, A. Jones, L. Tesillo, S. Strout, F.
Ellsworth

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The Enhancement of Gas Pressure Diagnostics in the P-ODTX System

Peter C. Hsu, Aaron Jones, Lynda Tesillo,
Steven Strout, and Fred Ellsworth
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Lawrence Livermore National Laboratory
Livermore, CA 94551

The One Dimensional Time to Explosion (ODTX) system at the Lawrence Livermore National Laboratory is a useful tool for thermal safety assessment of energetic material. It has been used since 1970s to measure times to explosion, threshold thermal explosion temperature, thermal explosion violence, and determine decomposition kinetic parameters of energetic materials [1, 2]. ODTX data obtained for the last 40 years can be found elsewhere [3, 4].

In 2014, we added pressure measurement capability to the system, referred as P-ODTX [5]. When energetic material is heated in a confined space, pressure increases slowly at low temperature. As the temperature increases, thermal decomposition accelerates resulting in higher gas pressure until thermal explosion occurs, at which time gas pressure increases very rapidly, often exceeding the seal pressure of the ODTX system (22,000 psia). In 2016, we upgraded the data acquisition system by revising the control codes in the Lab-View, adding a new Scope and a new Amplifier. The upgrade allows us to monitor gas pressure right before thermal explosion, which is important for the validation of cook-off models. Figure 1 shows the gas pressure of HMX powder when heated at 1 C/min ramp rate until thermal explosion occurred at 218 C. Gas pressures went up to 80 bars (1165 psia) that were recorded before the data acquisition upgrade.

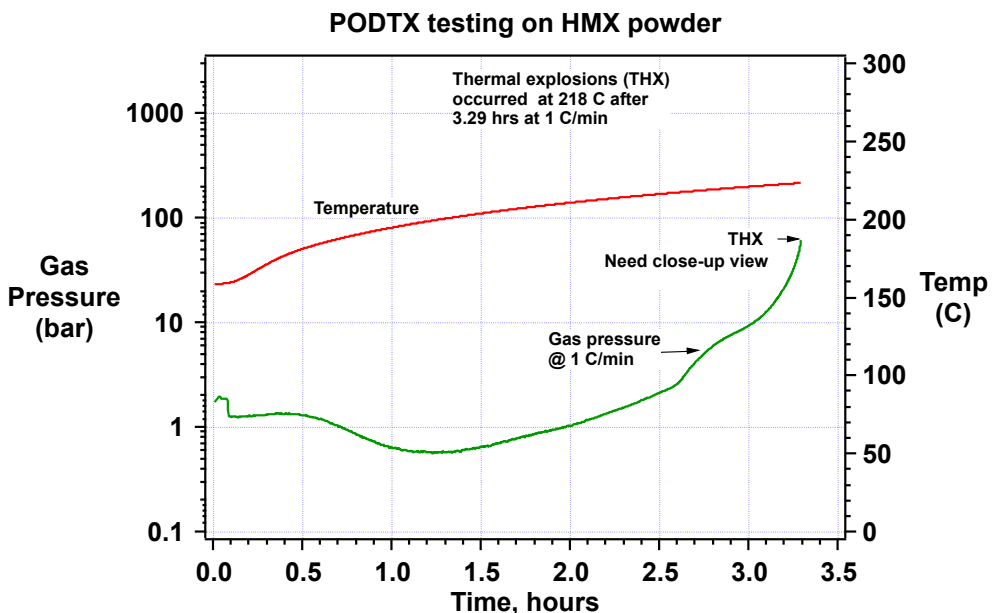


Figure 1: Gas pressure of HMX when heated in the PODTX system at 1 C/min ramp rate; gas pressure dips were due to pressure transducer noise, which is normal.

Figure 2 shows the gas pressure data after the upgrade. The gas pressure increased from 300 bars to 1156 bars in 10 microseconds before thermal explosion.

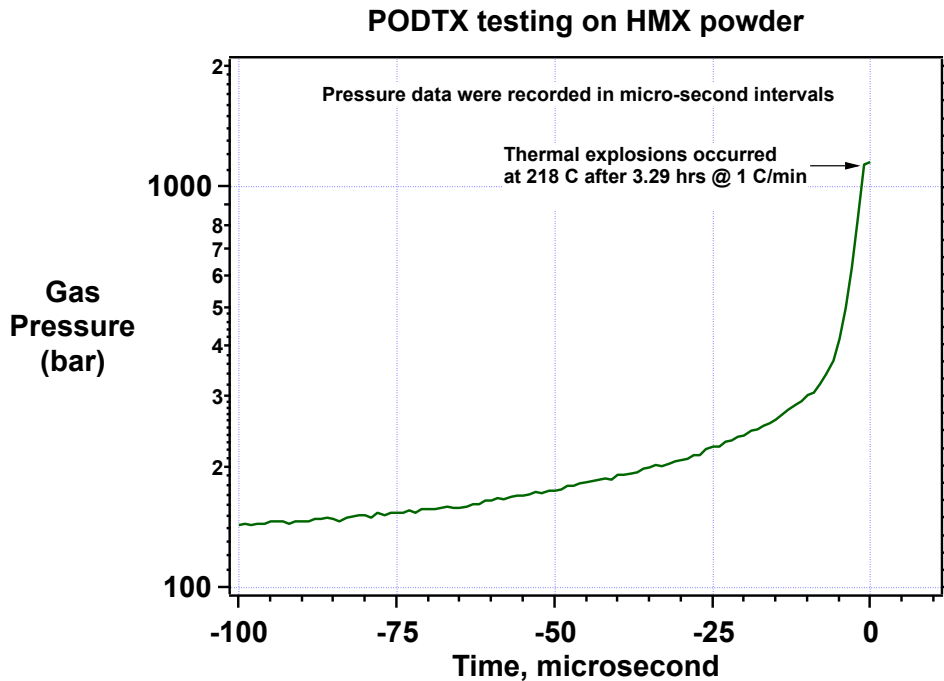


Figure 2: Gas pressure profile of HMX powder, 100 microseconds before thermal explosion when heated in the PODTX system at 1 C/min ramp.

Conclusion

After the recent upgrade to the data acquisition of the P-ODTX system, gas pressure measurements in microseconds have been achieved. The new capability allows for pressure data to be recorded right before thermal explosion occurs. The data will be crucial for the validation of cook-off models for thermal safety assessments of weapon systems.

History of ODTX system at LLNL

1. Built in house by E. Lee, R. McGuire, E. Catalano, D. Ornellas in early 1970s
2. Sent ODTX units to AWE, Pantex in 1980s
3. Built new ODTX unit in 2000 (current unit in service)
4. Added pressure measurement capability (P-ODTX) in 2014
5. Upgraded data acquisition system in 2016
6. Adding gas composition analysis capability to the ODTX system (C-ODTX), still under development (2016-), not yet available to use

ODTX data acquisition system

- Data collection frequency (from 1970 to 2015): every 19 seconds (adequate for regular ODTX tests, not fast enough for P-ODTX tests)
- Data collection frequency (from 2016): every 9 seconds (slow) to 5 seconds (fast) to micro-seconds (super fast with a new Scope and a new Amplifier). This is fast enough for P-ODTX tests.

Acknowledgements

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